Chapter 14
Experimental–Theoretical Method for Defining Physical–Mechanical Properties of Polymer Materials with Regard to Change of Their Physical–Chemical Properties

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ABSTRACT

In this paper, an experimental-theoretical method is suggested for defining physical-mechanical characteristics of polymer materials with regard to influence of corrosive liquid media. Experimental dependences of mechanical characteristics on a swelling function are given for a series of polymer materials. One dimensional and three-dimensional linear-elastic models of body deformation with regard to influence of corrosive liquid media are suggested. A new phenomenon, bulging of a polymer strip rigidly fastened by both ends because of swilling forces, is established. The stability criterion is given for a strip made of a polymer material situated under the action of swelling forces only.

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INTRODUCTION

Operational characteristics of structures made of polymer materials working in contact with corrosive and gaseous media sharply decline. Influence of corrosive media is not restricted by a surface action, it is of volumetric character.

Gaseous and liquid media diffuse intensively into internal layers of the material change their chemical composition, called swelling and change of physical chemical properties of polymer materials.

Influence effect of corrosive liquid media appears in the form of physical and chemical actions. The first one leads to reversible changes in the material's structure (swelling, dissolution) that disappear after removal of medium. The second one leads to irreversible changes in polymers structure. As a consequence of diffusion, gas formations, chemically active ions and free electrons are washed-out from polymer's micropores in certain extent (Reitlinger, 1970; Tikhomirov, 1970; Stepanov & Shlenskiy, 1981).

The problem on diffusion of liquid and gaseous media into polymer materials is studied since the middle of the last century. The direction of physical-chemical polymer materials has been most developed. In particular, mechanism of mass transfer of corrosive liquid and gaseous media into polymer materials with regard to the course of chemical reactions has been created, the solution methods of differential transfer equations has been worked out. In the mathematical plan the system of differential mass transfer equations with boundary conditions allowed to get not only the most total information on the laws on the diffusing substance in the material in the course of time but also to study the influence of basic factors on this distribution of the sizes and configuration of a polymer body, properties of a diffusant and change of concentration of chemical components and etc. All these problems compose a chain of investigations of diffusional processes in the sections of physical chemistry and physics of polymers. The works of Lykov, Groot, and Masur (1967) are fundamental works in this direction. The design method of mechanical resistance and mass transfer under laminar motion of incompressible liquid with variable physical properties of a pipe with porous walls was suggested by of Eroshenko, Zaychik, and Zorin (1980; Eroshenko & Zaychik, 1984). Reitlinger has experimentally and theoretically studied the process of permeability of liquid media into polymer materials (1970). Influence of corrosive factors on the diffusion process in a polymer material has been experimentally investigated by Tikhomirov. Time dependence of velocity of corrosive liquid has been established (Tikhomirov, 1970). Manin and Gromov (1980) and Shen, Chen, and Huang (1976) have researched physical-chemical resistance of polymer materials in commercial operation conditions.

As for the problem of mechanical resistance and deformation of structural elements made of polymer materials in the corrosive medium, this problem is at its initial stage of development. Stepanov and Shlenskiy (1981) have suggested an engineering procedure of strength analysis of structural elements made of plastic and operating in corrosive liquid medium. Dependence of limiting value of mechanical stress in the polymer on the character of diffusion of corrosive alkaline and acid medium is established (Stepanov & Shlenskiy, 1981). Zuyev (1972) and Tynniy (1975) theory of strength and failure of polymers under the action of corrosive liquid media have elaborated. Strength characteristics of polymer and composite materials under the joint action of corrosive oil medium and temperature have been experimentally investigated by Aliyev and Habibov (1994). It was experimentally established that softening of a polymer material happens under the action of temperature and this leads to decrease of its mechanical strength, change of physical-chemical properties and also variability of mechanical characteristics of polymer materials (Aliyev & Habibov, 1994). In the fundamental works of Ilyushin and also of Urzhumtsev, Malmeister,